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FARM  
BULK STORAGE  
FOR SMALL GRAINS



**T**HE INCREASING USE of the combine harvester in many grain-producing areas, the present practice of paying premiums for wheat of high protein content, and the economic waste incident to the marketing of grain containing foreign material or dockage, has created a need for increased farm grain-storage facilities for wheat and other small grains. Faulty grain storages account for heavy losses due to the heating of grain in bins, to rodents, to excessive labor in handling, and to the rapid deterioration of structures. This bulletin explains the losses due to faulty construction, suggests better building methods, and presents designs for several types of storages for small grains adapted to wheat-belt conditions.

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# FARM BULK STORAGE FOR SMALL GRAINS

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## INTRODUCTION

WHEAT generally ranks fourth in volume and also in value among all our farm crops and plays an important part in the commercial life of the Nation. A large proportion of the wheat crop each year is marketed from the farms within a few weeks after harvesting. The other small grains including rye, barley, flax, and grain sorghums are also marketed from the farm in large volume during the first weeks after harvesting. As a result the country elevators, the railroads, and, in turn, the terminal elevators are likely to be overtaxed. Orderly marketing would help to prevent market gluts and embargoes, which frequently result in lowered prices.<sup>1</sup>

The farmer's granary is in a sense his bank, in which he may deposit the whole or a part of the grain resources of his farm; it provides a source of income to be drawn upon as required. The agricultural marketing act makes it possible in certain States and under certain conditions, to obtain a loan on wheat stored on the farm. The farmer is thus enabled to take advantage of what he considers to be favorable markets.

Farmers who are not equipped with storage facilities sometimes are compelled to pile their newly threshed grain on the ground, where often it is spoiled by rains. Large quantities of grain arrive at the terminal markets each year in a musty, sour, or heated condi-

<sup>1</sup> U. S. Dept. Agr. Leaflet 46, Farm Grain Storage.

tion. Damaged grain is graded according to the damage and frequently it is sold on the market at a heavy discount.

It is the purpose of this bulletin to aid the grain grower in planning proper storage for his grain in order to avoid losses due to grain damaged by improper storage, and to sell his grain to the best advantage.

## FACTORS AFFECTING GRAIN IN STORAGE

### MOISTURE CONTENT

The moisture content of wheat and other grains affects the grading and consequently the market value of the grain. The percentage of moisture present in newly threshed grain usually depends upon whether or not the grain was mature when it was harvested and threshed, the weather conditions during harvesting and threshing, and the extent and manner of exposure of the threshed grain to the weather. Small grains in the spring-wheat area, when in sound marketable condition, have a normal moisture content at time of threshing of from 11 to 14.5 per cent. In dry-land areas the normal moisture content of the grain usually is less than in the spring-wheat area. The United States grain standards (grades) specify that the maximum moisture content for grade No. 1 shall not exceed 14 per cent for spring and durum wheats and 13.5 per cent for all other wheats, 14.5 per cent for barley and oats, 14 per cent for grain sorghums, and 13 per cent for rye.<sup>2</sup>

Grain containing a moisture content in excess of these maximums is given a lower grading. Good, clean grain containing not more than the maximum amount of moisture permitted in grade No. 1 is considered to be sufficiently dry for safe storage. A lower moisture content is required for safe storage of grain that contains an appreciable quantity of broken kernels, weed seeds, or other dockage, because of the greater probability of its heating in the bins.

The climate in which wheat is grown affects somewhat the character of the kernel and in turn the storage requirements. Harvesting of wheat starts in the South early in June, and ends in the North near the Canadian border usually in September or October. The climate to which wheat is subjected varies in the different areas and as the harvest season advances. In some sections, particularly in the northeastern part of the hard winter-wheat area and in the spring-wheat area of the Great Plains, the nighttime rainfall and the relative humidity of the atmosphere from June to October (the months of harvest) usually is much greater than that in the daytime. The relative humidity at night is often as high as 90 per cent, and heavy dews are frequent. Wheat harvested during the day in such regions is subjected to lower night temperatures and to higher humidities than that harvested in regions of less varied temperature, and these factors affect the amount of moisture in the harvested grain and particularly that in the grain which is harvested during the forenoon hours of the day.

The areas having a dry summer climate produce dry grain requiring, so far as moisture in the grain is concerned, but cheap storage

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<sup>2</sup> U. S. Dept. Agr. Handbook of Official Grain Standards. 1929.

on the farm, while the more humid sections usually produce grain of higher moisture content requiring greater care in handling and storage to prevent the grain from going out of condition.

Under normal conditions in the arid States of Arizona and Utah and in the inland portions of the Pacific Coast States the grain usually is mature and very dry at time of threshing. Such grain, owing to absorption of moisture from the air, increases in weight during storage in the rainy season following harvest and particularly after the grain has been moved to the seaboard markets. If the grain is not thoroughly air-dry at harvest there will be direct evaporation of moisture and a shrinkage in the total weight of the grain while it is in storage. In the more humid areas, if the threshed grain is either immature or contains excess moisture, evaporation of the excess moisture is necessary before the wheat can be safely stored. Grain stored in Ohio for five years showed a variation in weight of from plus 1 per cent to minus 2 per cent. Samples taken hourly from standing wheat in the fields of North Dakota in 1927 contained from 18 to 19 per cent of moisture early in the forenoon and, under weather conditions favorable for drying, 14 per cent in the late afternoon. After sundown the moisture content of the wheat increased rapidly and again reached 18 to 19 per cent during the night.<sup>3</sup> The rate at which standing grain dries depends chiefly upon the humidity of the atmosphere, the temperature, and the velocity of the wind.

The moisture content of stored grain varies approximately with the humidity of the atmosphere, but this relation is affected to some extent by temperature. Changes in air humidity for short periods have very little effect on the weight of grain in storage. The change in weight of grain stored in large bulk is very slow, the rate of change depending upon the bulk and upon the amount of the air circulation through the grain. In a very large mass only the grain near the surface will be affected to an appreciable extent.

Stored grain may heat whenever its moisture content is more than is permitted for grade No. 1. Even grain of the maximum moisture content specified for grade No. 1 may not always be safe for storage. For instance, when it is stored under conditions which may cause condensation of moisture on the bin walls and roofs, or when the grain is subjected to the sun's heat, the grain may be damaged unless it is ventilated. Grain absorbs free water rapidly and under certain conditions readily takes up moisture from the atmosphere.

Condensation of moisture occurs when warm, humid air comes in contact with a surface the temperature of which is below the dew point<sup>4</sup> of the surrounding air. Walls and roofs, when colder than the damp air within the storage bins, may act as condensing surfaces. The extent of condensation will vary with the rate at which heat is transmitted through the walls and roofs and with the rapidity and frequency of climatic variations.

When damp grain is put into storage, condensation occasionally is the cause of an increase in the moisture content of that part of the grain which is at the top surface of the mass and along the sides of metal and concrete bins. Condensation therefore is an important

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<sup>3</sup> U. S. Dept. Agr., Bur. Agr. Econ. Preventing Damage in Spring Wheat Harvested with Combine. June, 1928. [Mimeographed.]

<sup>4</sup> The dew point is the temperature at which the moisture will begin to condense in the form of tiny droplets or dew.

factor in the design of storage structures. It is sometimes difficult to distinguish between the effects of leaks and those of condensation. Dampness in grain sometimes is attributed to leakage when condensation is the cause.

#### HARVESTING METHODS

New methods of harvesting and threshing have introduced new problems in grain storage. Where binding and shocking is practiced the grain-moisture hazard is in general less than it is where the grain is "combined" as is now the case in many areas. Any damp grain which is harvested with the binder, and any green weeds that are cut with the grain, have a chance to dry out in the shocks, and the weed seeds can more readily be separated from the grain during threshing.

When the combine is used direct, the grain should be dead ripe and dry at the time of harvesting and should stand in the field from a week to 10 days longer than when the binder is employed. A heavy growth of green weeds high enough to be cut by the combine results in a higher percentage of moisture in the mixture of grain and weed seeds than the grain itself contains. Weeds are more common in the spring-wheat than in the winter-wheat areas.

Green weed seeds found in "combined" grain may contain more than 60 per cent of moisture. When the grain in a mixture of grain and green weed seeds is dry it can be safely stored after the weed seeds have been removed. If it is stored without cleaning, the excess moisture in the weed seeds is readily transferred to the wheat kernels and fermentation is likely to occur. This condition in the spring-wheat area, where weeds are quite prevalent in the grainfields, has led to a common use in that area of the windrower, whereby the grain and weeds may be cut and dried in the swath.

The transfer of moisture from green weed seeds to drier grain kernels is quite rapid. It has been found, in the case of wheat held in a wagon box overnight, that by early morning much of the excess moisture in the weed seeds had been transferred to the wheat. Such grain should be cleaned before it is put in storage. In 1929 the average dockage in wheat threshed in North Dakota amounted to over 5 per cent, and during the same year the average dockage in the flax threshed in that State amounted to over 17 per cent. The production of weed-infested grain results in large loss since it adds to the cost of harvesting, threshing, and handling, and if the wheat is not cleaned before it is sold on the market its commercial grade and market value is lowered. Farm storage affords opportunity to clean the grain on the farm, and the screenings or dockage can often be profitably used for feed.<sup>5</sup>

#### HEAT DAMAGE

Excess of moisture at the time of storing is largely responsible for "out-of-condition" grain. Under favorable conditions of temperature and moisture, fermentation of stored grain occurs. As fermentation proceeds the temperature of the grain rises, resulting in sour, musty, and heat-damaged grain, which adversely affects its

<sup>5</sup> U. S. Dept. Agr., Bur. Agr. Econ. Screenings as Feed for Livestock. May, 1924. [Multigraphed.]

germination and feeding values, as well as its milling or manufacturing qualities. Damp grain in storage therefore should be kept cool and well ventilated.

The loss due to "out-of-condition" wheat and other grains is large. The difference in price between sound and heat-damaged grain usually ranges from 5 to 15 cents or more per bushel depending upon the extent of the damage. It is always a safe practice to examine the grain frequently and at the first indication of heating to aerate the grain by transferring it to another bin, repeating the process as often as may be necessary to reduce the temperature and to stop fermentation. Although this can readily be done in the local country elevators it is not easy to do on the farm unless extra storage space and grain-handling machinery is available. The farm storage should be so designed as to enable the farmer to change heating wheat from one bin to another quickly and with little labor. This involves the installation of elevating equipment, which is now available on the market for use in farm storage.

#### REDUCING MOISTURE CONTENT

The moisture content of damp grain may be lowered by any one or by a combination of several methods, such as delaying the harvest until the grain is dry, mixing the damp grain with dry grain, using ventilated bins or artificial driers, and by employing construction materials that prevent the rapid passage of heat through the bin walls.

It is highly desirable that combining and threshing be delayed until the grain is dry enough to be safely stored. However, weather conditions during the harvesting and threshing period are at times such that it is difficult to avoid damp threshed grain. Damp threshed grain must be dried in some manner if spoiling in storage is to be avoided. When the grain contains only a slight excess of moisture it can be dried on the farm by placing properly constructed ventilators in the bins (p. 24), by mixing small quantities of the damp grain with other grain of the same kind which is thoroughly dry, or by frequently moving it from one bin to another on warm dry days. To employ either of the two last-mentioned methods requires grain-handling machinery for practical results. To mix damp grain with dry grain is practical only when the moisture content of the dry and the damp grain is such that the moisture content of the mixed grain will be sufficiently low for safe storage.

When the newly threshed grain is of a high moisture content it is a common practice to deliver it immediately to a local elevator or to ship it to a terminal market, where it may be kept in good condition by being dried, mixed with dry grain, or frequently moved from bin to bin. However, during periods of heavy deliveries from the farms the local elevators often have difficulty in successfully handling large quantities of damp and wet grain, with the result that such grain frequently takes a heavy discount in price and often will not be accepted at the elevator at all.



Some country elevators are equipped with artificial driers in which the moisture content of damp grain may be reduced to a point for safe storage.<sup>6</sup>

Driers of suitable capacity for farm use may be had, but at the present time the high initial cost prohibits their general employment on farms.

### PLANNING GRAIN STORAGES

The farm storage may consist of an elevator, a granary, portable bins, or emergency bins. Before the building is started, decision should be made as to whether the shelter is to be temporary—providing for only immediate needs—or one that is substantial, permanent, and capable of expansion as future needs may require.

It is unwise to attempt to erect any substantial building, particularly large grain storages, without carefully prepared plans. Unless each feature of the construction, arrangement, and equipment is studied and its relation to other features definitely determined before erection is started, costly mistakes may be made. Errors in design are easily corrected, on paper. Changes in the completed or partly finished structure may prove very expensive.

Lack of knowledge of the strength of materials on the part of the builder, poor judgment in the selection of the site, and poor workmanship have caused many failures of grain storages. It is inadvisable to trust inexperienced builders with such construction. The errors most commonly found are faulty foundations and insufficient bracing and tying. Overloading also is a frequent cause of failures. Farmers, in building new structures, frequently copy existing buildings in their locality. Many good ideas may be obtained from one's neighbors, but to follow too closely is often a mistake, as conditions and requirements vary. The farm granary should be so designed as to meet the requirements of the particular farm. No one type of granary is suitable for all conditions of grain farming.

The granary should be located conveniently with respect to the movement of trucks or wagons to and from the fields. The site should be well drained and in such relation to other buildings as not to mar the appearance of the farmstead. If the granary is to be used in connection with cattle or stock feeding, careful planning will save much labor and time in caring for the stock.

### SPACE REQUIREMENTS

The size of the granary is determined by the average quantity of grain to be stored each year. It is desirable to provide a number of bins of convenient size to permit the separation of the wheat into different grades and varieties, the old from the new, and the damp from the dry. It also permits of shifting grain from one bin to another to prevent heating. For this purpose a small extra bin should be provided, or the larger bins should be but partly filled. The bins may be numbered for convenience in keeping records.

A standard bushel of wheat occupies approximately  $1\frac{1}{4}$  cubic feet of space and weighs approximately 50 pounds per cubic foot. The capacity of a bin, in terms of bushels, may easily be calculated by

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<sup>6</sup> U. S. Dept. Agr. Circ. 127. Grain Drying at a Country Elevator.

multiplying its volume (length by breadth by depth) by 8 and dividing by 10.

In addition to grain-storage space, provision should be made, in permanent storages, for space and equipment needed to facilitate handling the grain in conditioning, cleaning, grading, treating, and grinding. The space and equipment will vary with the individual needs.

### STRUCTURAL REQUIREMENTS

#### MATERIALS

The essentials of a successful grain storage are sufficient structural strength and dryness. The selection of materials of construction and the manner in which they are assembled are of great importance. The materials commonly used in the superstructure are wood, concrete, hollow tile, and galvanized metal, the last being commonly used in dry-land areas. No one material may be considered superior for use under all the conditions. Some farmers may wish to convert an existing building, some may emphasize the desirability of fire-proofing, some may want to build in harmony with existing structures, and others may wish to employ certain readily available materials.

#### FOUNDATIONS

The foundations of grain storages must support a greater weight than do those of most farm buildings. Hence, they should be constructed of materials that will not crush, made wide enough at the bottom to carry the load without settling, and extend far enough below the surface of the ground to prevent heaving by frost. It never is advisable to place footings on top of the ground; rats easily burrow under them, as shown in Figures 1 and 2, and rains may wash the soil from beneath them (figs. 3 and 4), permitting the building to settle. Standing water in hog wallows or pools formed by drip from eaves may soften the soil under a portion of the foundation and cause unequal settlement.

The materials commonly used in the construction of foundations are concrete, stone, brick, hollow tile, and concrete blocks. A well-constructed foundation (fig. 5) insures uniform distribution of the weight of the building and contents on the soil, prevents unequal settlement and racking of walls, reduces repair bills, and prolongs the life of the granary.

Concrete foundation walls can not well be made less than 8 inches thick because of the characteristics of tools generally available for trench digging and the difficulty in properly placing concrete in forms of less width. For stability, brick walls must be made at least 8 inches thick. Stone walls should generally be 16 inches thick in order to obtain thorough bonding of the material, but if the stones are of suitable shape and care is taken in laying them they may be made 12 inches thick. Hollow tile and concrete blocks are not generally suitable for foundations carrying heavy loads. They may be used in foundations supporting light loads provided the material is sound and hard and the workmanship first class.

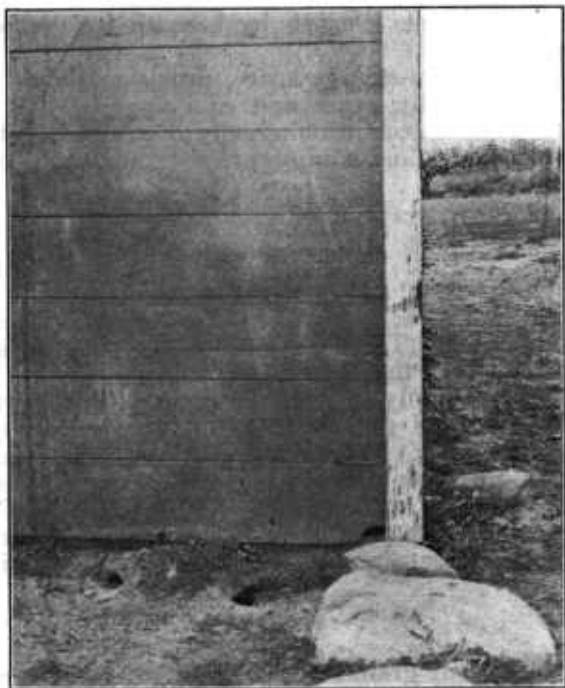


FIGURE 1.—Corner of a granary with poor foundation of insufficient depth to prevent easy entrance of rats



FIGURE 2.—A small granary set on a poor foundation and so close to the ground as to cause early rotting of sills and joists through dampness and to provide excellent harborage for rats

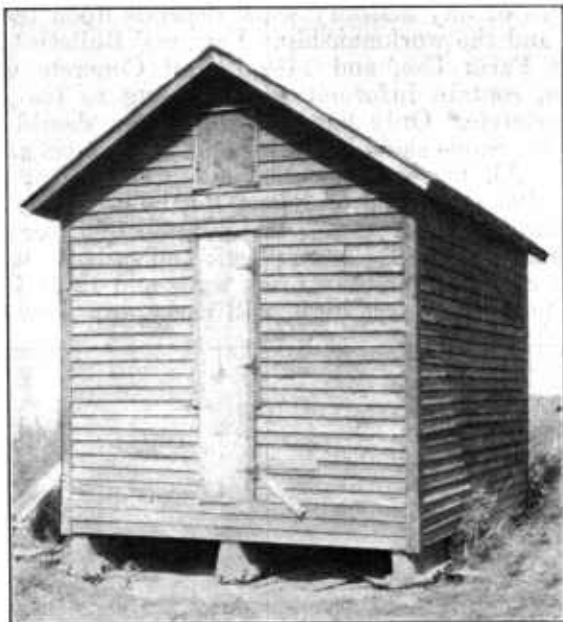


FIGURE 3.—A small granary of approximately 1,000 bushels capacity. The floor is raised sufficiently, but the footings are practically on top of the ground, affording no protection against frost action and soil washing. Design No. 2392 (p. 44) provides for a proper storage of similar type and capacity. Estimated cost, \$500

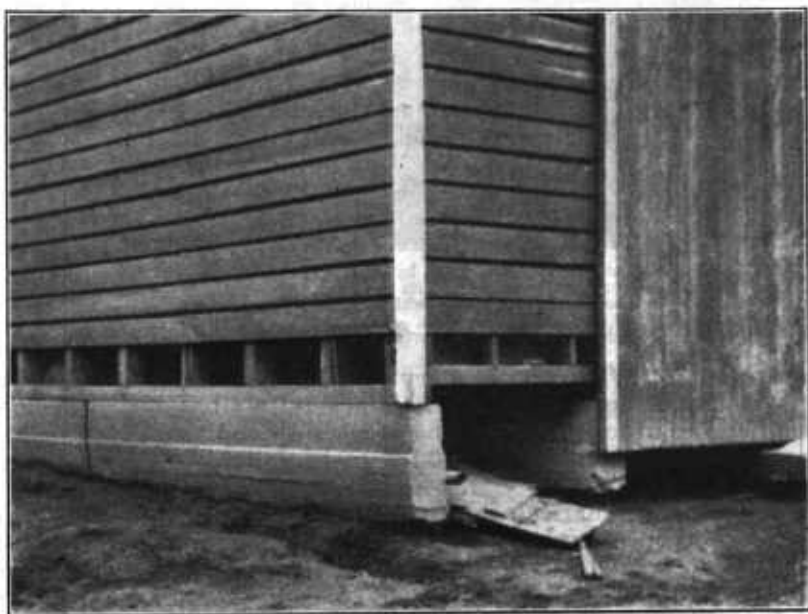


FIGURE 4.—A foundation made insecure by the washing away of the soil underneath

The strength of any masonry work depends upon the quality of the material and the workmanship. Farmers' Bulletins 1279, Plain Concrete for Farm Use, and 1480, Small Concrete Construction on the Farm, contain information pertaining to the mixing and placing of concrete. Only hard-burned bricks should be used in brick masonry. Stone should be selected for hardness and flat bearing surfaces. All masonry should be laid in mortar of strength not less than that consisting of 1 part Portland cement and 3 parts sand. The addition of 9 pounds of hydrated lime for each bag of cement will make the mortar more plastic and easier to handle.

Continuous 8-inch concrete or brick walls and 12 or 16 inch stone walls, when not over 6 feet high, will carry any load likely to be

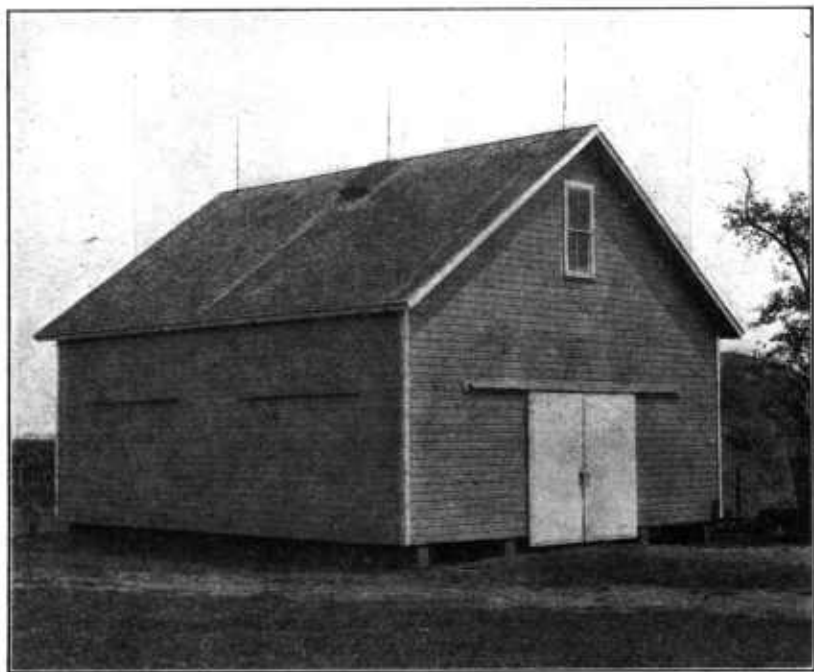


FIGURE 5.—An excellent farm granary, 30 by 32 feet, of 7,000 bushels capacity set on good 10-inch concrete walls with 16-inch footings. The sills are 18 inches above grade, allowing good air circulation, which is conducive to long life of timbers, and affording no harborage for rats. The building is well braced and tied together. It is filled by means of a portable elevator

placed upon them in farm-granary construction. Footings may not be necessary on some soils, but it is generally advisable to provide them in order to resist overturning of the wall and to provide against inequalities in the soil. Figure 6 illustrates failure due to insufficient footing.

The smaller granaries often may be more cheaply supported on piers and wooden girders. Concrete, brick, or stone piers 10, 12, and 16 inches square, respectively, if not more than 8 feet apart will safely support the loads incident to small-granary construction, but the soil beneath may not do so. In that case larger piers or footings must be employed to distribute the load on the soil. The footing must not be so thin as to crack under the load.

The bearing power of soil varies with its character and condition. For general use the following loads, in tons per square foot, may be considered safe on the kinds of soil specified: Dry clay, 4 to 6; moderately dry clay, 2 to 4; soft clay, 1 to 2; compacted gravel and coarse sand, 8 to 10; clean dry sand, 2 to 4; quicksand and alluvial soils one-half to 1.

The dimensions of a footing for a continuous foundation wall with a uniformly distributed load are roughly determined by dividing the total load, in tons, on the wall by the length of the wall in feet, the result being the load on each lineal foot of soil beneath the wall. The footing must project on each side of the wall to provide a bearing surface large enough on the basis of the safe loads given above, to support the load on each lineal foot of wall. The width of the footing having been determined, the thickness (height) should be made equal to the difference between the width



FIGURE 6.—A common type of multibin granary with a driveway through the center. Note failure of foundation at the right-hand corner, due to a footing too small for the bearing power of the soil

of the footing and the thickness of the wall. The foundation must be centered on the footing.

The dimensions of a pier footing may be determined in much the same manner. The area of the footing must be such that the load per square foot is less than the bearing power of the soil. The projection must be the same on all sides of the pier. Where the bearing power of the soil is low, wide footings may be necessary, particularly under piers. If, by reason of the width, the height of the footing is greater than 18 inches it may be stepped or beveled, thus saving concrete. Large granaries or elevators built on soil of low bearing power may require very wide footings, in which case it may be more economical to use steel reinforcement. Such structures may, on some soils, settle as much as 12 inches when filled, but no damage will occur if the settlement is uniform. Because of the many factors involved, foundations for such storages should be especially designed by competent engineers or builders.

Large field stones or boulders sometimes are used as piers and at times in continuous foundations. If they are not well chosen and placed, the result is unequal settlement of the building as shown in Figure 7. Such stones should be carefully selected for uniformity of size of flat bearing surfaces and should be set deep enough in the ground to avoid the effect of frost action.

The height of the foundation above the ground should be such that the sills and floor joists shall be supported a foot or more above the ground and the sills should be set in mortar so as to insure even bearing. If the building is set too close to the ground, as is the case in Figures 1 and 2, there is little chance for air circulation under the sills and joists, which will deteriorate rapidly. If the structure is set well off the ground, as shown in Figures 3, 5, and 7, the life of all base timbers is increased, and there are no dark, in-

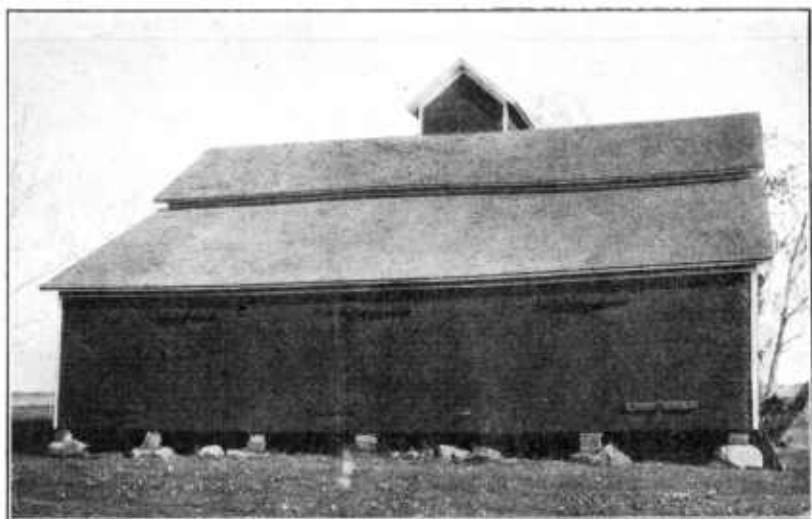


FIGURE 7.—Inadequate foundations cause settlement and racking of building

accessible places to harbor rats. If the foundation is a continuous wall completely inclosing the space under the granary, vent openings screened against rats should be provided to permit the circulation of air necessary to prevent the rotting of timbers. Such foundations make for the better appearance of the building, but two or more parallel bearing walls without end cross walls are cheaper and permit of better air circulation under the building as well as access for cats and dogs. (Fig. 5.)

#### FRAMING

Two general styles of framing—balloon and crib—are used in grain storages on the farm. The balloon type is most commonly used for structures under 8,000 bushels in capacity. In this type the walls consist of sheathed studs 12, 16, or 24 inches center to center. Examples of this type are shown in Figures 5, 7, and 8.

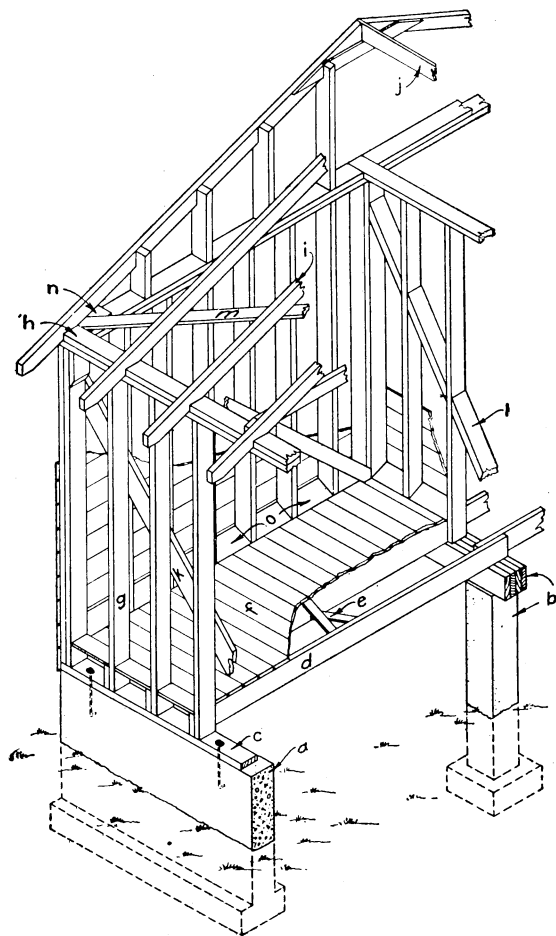


FIGURE 8. Framing of granary of balloon-type construction: *a*, Continuous-wall foundation; *b*, pier and girder construction; *c*, sill; *d*, joist; *e*, bridging; *f*, floor; *g*, stud; *h*, double plate; *i*, rafter; *j*, ridge pole; *k*, brace spiked to inside of the studs; *l*, brace cut between the studs; *m*, brace spiked to the under side of rafters; *n*, wedge block under end of rafter brace; *o*, beveled boards between studs



In the crib type (figs. 9 and 10) the walls are built up of 2-inch lumber laid flat and spiked together, the width being determined by the height of the structure. For buildings 24 feet or less in height, 2 by 4 inch lumber is used. In walls 24 to 40 feet high

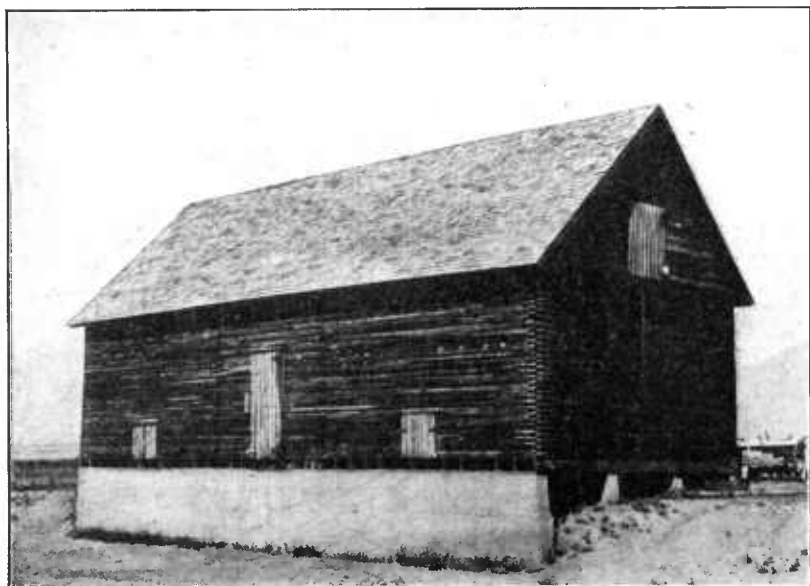


FIGURE 9.—Granary of the crib type, built on a bank side, with walls of 2 by 4 inch lumber

the lower 16 or 18 feet usually are built of 2 by 6 inch material; in walls of still greater height 2 by 8 or 2 by 10 inch lumber is employed in the lowest part of the walls with smaller timbers above. The crib type of framing is preferable when the storage capacity

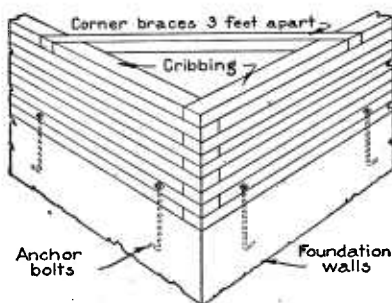


FIGURE 10.—Method of constructing crib walls.

exceeds 10,000 bushels. Figure 11 shows a metal-clad farm elevator of the crib type. This structure cost no more than a balloon-type building of the same capacity would have cost.

The strength of timber varies with the kind and grade. The cost of timber varies with kind and locality. The most common commercial timbers are oak, yellow pine, fir, spruce, white pine, hemlock, and cottonwood, named in the order of their relative strength. Large defects, particularly knots, greatly weaken timbers, but it is sometimes possible to sort them and to use the best timbers in those positions requiring greatest strength.

## STUDS

Balloon construction is not recommended for heights much greater than 24 feet. Only seasoned lumber should be used. Figure 12 illustrates a failure in this type of construction. The studs in this



FIGURE 11.—Farm elevator of the crib type. The metal covering gives protection against entrance of rain, saves painting and affords some protection against fire from the outside. The peculiar roof construction is due to the arrangement of the elevating machinery. A stairway provides easy access to the elevator boot.

elevator are 2 by 6 inches, spaced 12 inches center to center, and 40 feet high. The bins can not be filled to full capacity without danger of complete failure. Balloon structures of this height must be thoroughly braced and tied, which adds materially to the cost.

Table 1 gives size and spacing of studs which have been found satisfactory in common practice for single-boarded bins not over 12 feet deep. Since defects have a greater relative effect on the strength of 2 by 4 inch studs than on that of larger sizes, the 2 by 4 inch material should be selected with care.

TABLE 1.—*Size and spacing of studs for farm grain bins of various depths*

Depth of bin	Size of studs	Spacing of studs center to center	Depth of bin	Size of studs	Spacing of studs center to center
<i>Feet</i>	<i>Inches</i>	<i>Inches</i>	<i>Feet</i>	<i>Inches</i>	<i>Inches</i>
5	2 by 4	24	8	2 by 6	24
8	2 by 4	16	10	2 by 6	16
9	2 by 4	12	12	2 by 6	12



FIGURE 12.—Failure of an overloaded grain elevator of the balloon type of framing, 40 feet high with studs spaced 12 inches center to center. In addition to the failure of support at the driveway the walls have bulged

## BRACES AND TIES

Particular attention must be given to the providing of braces and cross-ties in order to prevent overstraining and bulging of studs. Their omission is a common fault in storage structures, and as a consequence many buildings are found in the condition shown in Figures



FIGURE 13.—Lack of proper bracing—a too common fault—results in distortion of the building. A high foundation increases the life of sills and joints. Rodents can not climb metal-covered posts

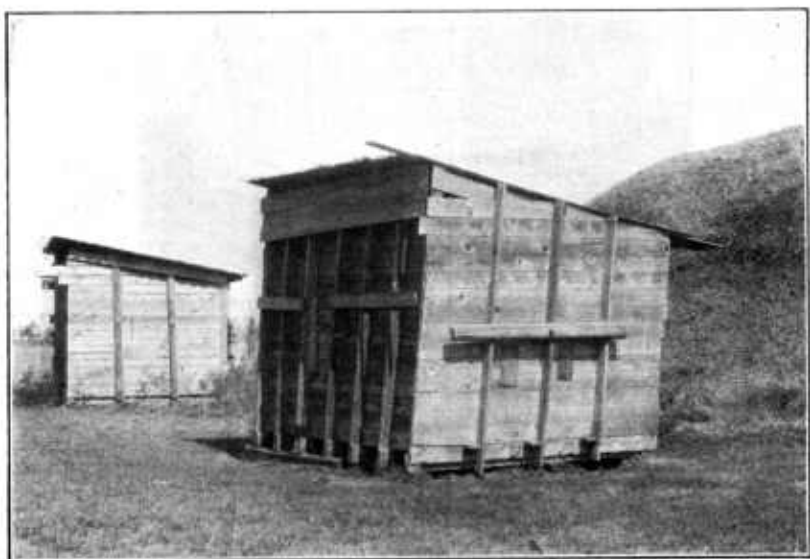


FIGURE 14. Portable bins of 600 bushels capacity with no bracing to prevent racking by wind or strain in moving. Bulging of the studs was due to an insufficient number of ties. The bins are filled directly from the thresher

13 and 14. Such failures may be avoided by the use of a few braces well spiked to the side of the studs or cut in between them. Braces let into the studs weaken them and may lead to early failure of granary walls. The wall bracing in Figure 8 illustrates two of the most common methods of strengthening and stiffening stud walls. The brace *k* is spiked to the inside of the studs; brace *l* consists of short pieces cut in between the studs. Brace *k* should be of nominally 1-inch material, as wide or wider than the studs, and must be well nailed especially at the ends. Brace *l* should be of the same dimensions as the studs; to be efficient the joints must be well made and thoroughly spiked. Brace *k* is the more efficient. Brace *m*, extending from the junction of the end and side walls with the roof to the ridgepole, is spiked to the underside of the rafters. With such



FIGURE 15.—A farm elevator of the balloon type of 7,500 bushels capacity. The building, including stay timbers for the tie rods, is metal-clad

a brace at each corner any tendency of the roof to sag is overcome. Bracing of the roof rafters is particularly desirable in the larger structures.

Wire ties sometimes are used in small structures. In the larger structures  $\frac{5}{8}$  to  $\frac{3}{4}$  inch rods are spaced  $3\frac{1}{2}$  to 4 feet apart. (Figs. 12 and 15.) Where the height of the walls is from 6 to 10 feet one or more ties, depending upon the length of the wall, usually is sufficient. In walls of greater height, two or more sets of ties are required. (Figs. 7 and 15.)

Figure 16 shows the failure of a farm granary, 12 by 32 by 10 feet after but a few months of use. The studs are 2 by 6 inches and are spaced 24 inches center to center. The wire ties, too few in

number and placed too high, proved inadequate, with the results as shown. The greatest outward thrust appeared to be on the lower 4 feet of the wall. Since ties at this level would interfere with the headroom, the studs should have been larger or more closely spaced. Ties should be used wherever the depth of stored grain is over 6 feet. In shallow bins the ties may be placed 6 feet from the floor, but in bins more than 10 feet deep lower ties are necessary. The stay timbers, to which the ties are secured, often are spiked to the outside of the studs. Unless they are protected by flashing, as shown in Figure



FIGURE 16.—Failure of a new granary due to overloading and inadequate tying and nailing

17, A and B, water gets behind them and causes rotting of both sheathing and timber. Sometimes they are fastened on the inside of the studs by means of wagon-box strap bolts (D). The use of U or hook bolts is shown in E. In placing these bolts the studs should not be notched as this weakens them. The tie rods extend through the stay timbers (E), or they may be secured to studs with fastenings similar to hay-track ridgepole brackets as shown in D. The first method is preferable as it provides the better anchorage, and turnbuckles are not necessary. The latter method is better adapted to installation in bins already erected.

## JOISTS

The size of joists required varies with the span and the depth of grain. In the deeper bins the arching action of the wheat tends to put part of the load on the walls, decreasing the load on the joists. The clear span of the joists should not be more than 10 feet. Driveways should not be more than 10 feet in width if bins are to be erected above them. Cross grain or twisted joists, or joists with long end splits, should not be used. Knots on or near the lower edge of a joist have a weakening effect and should not be permitted if the average diameter is more than one-eighth of the height of the joist. Knots on the top of joists are much less objectionable, and knots in the center of the height have little influence on the strength of the timber.

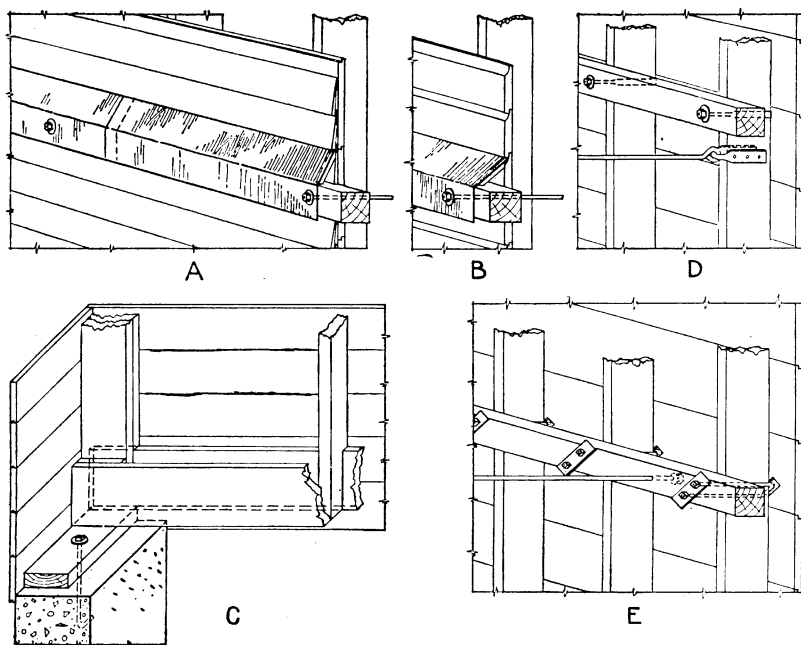


FIGURE 17.—Bin-wall details: A, Exterior stay timber with flashing on double-boarded wall; B, flashing with single boarding; C, framing of studs, joists, and sill at corner of a granary; D, stay timber secured with wagon-box bolts, the tie rods being secured to studs; E, inside stay timber secured to studs with U bolts, the tie rods extending through the timber

As a rule, much greater strength for a given amount of material can be obtained by increasing the height of a joist rather than the width. However, the height preferably should be limited to not more than six times the thickness and not more than one-tenth of the length of the span.

The joists should be bridged to prevent twisting and turning under the load. The ends of the joists should be spiked to the studding and to plates or sills of ample bearing surface. Good construction is shown in Figure 8. Proper framing at the corner of a granary is

shown in Figure 17, C. Where piers are used the heavy sill should be securely bolted to each pier. The joists should be not more than 24 inches on centers, and usually not less than 12 inches, depending on the size of joists and the load to be supported.

Table 2 gives suggested sizes, spans, and safe loads for joists supporting different depths of wheat in the bin. These figures must be considered only as a guide intended to lessen the liability to failure. The knowledge and experience of the builder with respect to the kind and quality of the lumber used may make departure from these values desirable.

TABLE 2.—*Safe, uniformly distributed loads for joists*

Size, inches	Safe load for a 1—				
	6-foot span	7-foot span	8-foot span	9-foot span	10-foot span
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
2 by 6 .....	1, 150 to 1, 700	1, 000 to 1, 450	900 to 1, 300		
2 by 8 .....		1, 750 to 2, 600	1, 550 to 2, 300	1, 300 to 2, 000	
2 by 10 .....		2, 800 to 4, 200	2, 400 to 3, 600	2, 150 to 3, 250	1, 900 to 2, 900
2 by 12 .....			3, 600 to 5, 400	3, 200 to 4, 800	2, 900 to 4, 300

<sup>1</sup> The higher values for each span apply to the stronger woods such as oak, yellow pine, and fir of good grade; the lower values to woods of less strength.

#### FLOORS

All floors should be tight and smooth. Tightness is particularly necessary where the grain is to be fumigated; in such cases the floors should consist of two layers of tongue-and-groove flooring with paper between them in order to prevent the escape of the gas. Wood floors should be constructed of well-seasoned, dressed, and matched flooring to avoid cracks due to shrinkage. The low foundation shown in Figure 2 does not permit air circulation whereas the construction shown in Figure 5 protects timbers from dampness. Although the building shown in Figure 13 has been in service for more than 50 years the joists and sills are still in good condition.

A concrete floor should be smooth with all joints between walls and floor made water-tight. Directions for laying concrete floors are given in Farmers' Bulletin 1572, Making Cellars Dry. All concrete floors should be waterproofed (p. 22).

#### SHEATHING

The studs of granary walls may be sheathed on the inside or the outside, or both. If they are sheathed on the inside, ship-lap or matched lumber should be used. This is generally done in temporary structures, the studs and sills being exposed to the weather. Novelty or drop siding may be used on the outside. Ship-lap also may be used on the outside, but in some regions it should be covered with beveled or drop siding as protection from the weather. Inside boarding of permanent bins within a building facilitates cleaning, but it reduces the capacity of the bin and provides inaccessible spaces where



rats may harbor. The construction shown in Figure 18 makes for ready cleaning at much less expense and does not lessen the capacity.

Plain, square-edged boards sometimes are used for sheathing, but this is not advisable since shrinkage cracks between the boards are sure to occur and grain will be lost. Moreover, plain boards do not provide sufficient protection against wind-driven rains. For these reasons in the spring-wheat area the walls often are double-boarded, sometimes with building paper between the layers. The walls should be so constructed wherever fumigation of the grain is likely to become necessary.

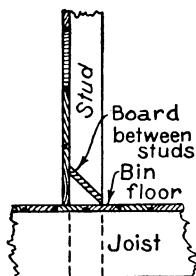


FIGURE 18.—Beveled boards cut between the studs facilitate the cleaning of bins

The sheathing boards should be well nailed. Two tenpenny wire nails at each stud should be used in outside boarding of deep bins where they must resist considerable grain pressure. The strength and stiffness of a horizontally sheathed wall in which two tenpenny nails are used at each stud is about 40 per cent greater than when two eightpenny nails are used. Two eightpenny nails are sufficient to hold inside boarding in place. A failure partly due to inadequate nailing is shown in Figure 16. Figure 11 shows a farm elevator sheathed with metal to protect the woodwork.

The nails used to secure the metal were too small. Failure was due to shrinkage of the wood and expansion of the metal which pulled the nails over a large area, allowing one section of the metal covering to drop. The use of larger nails—either barbed or coated—would have prevented this.

#### WATERPROOFING

If the walls are of concrete, brick, or building blocks, especial attention must be given to making them absolutely water-tight. Entrance of water through cracks or mortar joints, or through the wall material itself, must be prevented. One method of doing this is to apply waterproofing paint of proved value to the inside and outside surfaces, as was done on the structure shown in Figure 19.

Walls of solid concrete, brick, or hollow building block 8 inches thick should be satisfactory in moderately warm, dry climates, provided they are kept dry by a protective coating. In regions subject to extremes of temperature and humidity, insulation in addition to waterproofing may be necessary, especially for the safe storage of grain that is not thoroughly dry. However, leaking walls often are the result of poor workmanship. If the materials are of good quality and properly placed further protection may not be necessary. On a well-drained site a dry concrete floor may be obtained by leveling the ground and laying the concrete on top of a well-compacted layer of gravel, crushed stone, or cinders 6 or 8 inches deep; but positive assurance of a dry floor may be had only by placing a layer of waterproof material under the concrete. Methods of waterproofing concrete floors and walls are described in Farmers' Bulletin 1572, Making Cellars Dry.

The joints in metal bins sometimes leak, but more often moisture found on the inside is due to condensation. Asphalt paint often is

applied to metal bins to prevent leakage and to protect the metal. (Fig. 20.) This should not be done unless a coat of white paint is applied over it, as black paint tends to raise the inside temperature.

#### INSULATION

Condensation of moisture within the bin, often the cause of spoiled grain, will not occur if the grain is thoroughly dry or if the temperature of the inside surfaces of the walls and roof is kept above the dew point (footnote 4, p. 3) of the air within the bin. This may be accomplished to a certain extent by the use of insulation, that is,

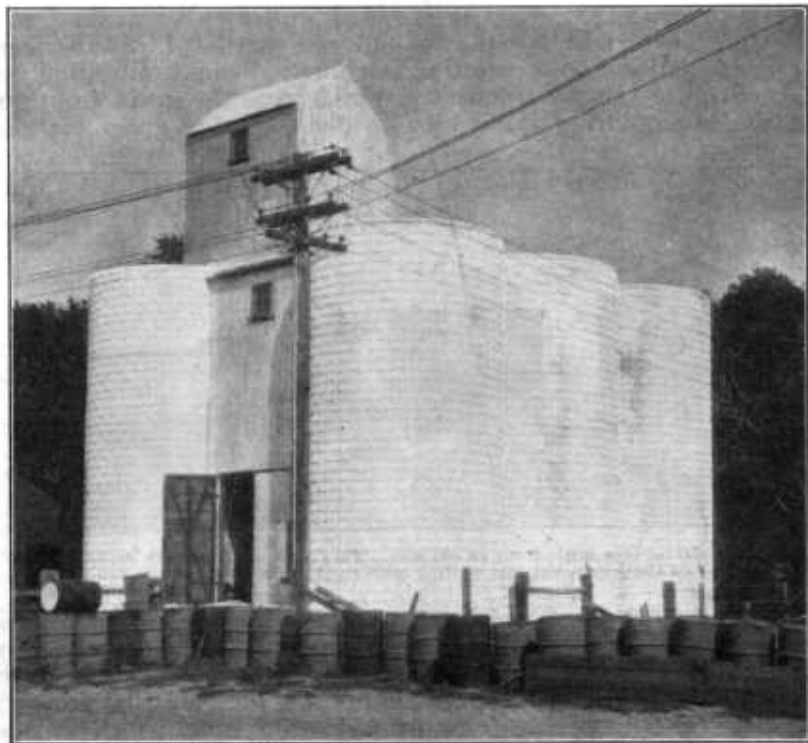


FIGURE 19.—A new farm granary built of concrete blocks which have been painted with a waterproofing paint

such construction as will prevent too rapid lowering of the inside temperature next to the bin walls and roofs. As warm, moist air rises to the top of the bin, the insulating of roofs is of greater importance than that of side walls. If, however, the temperature of the inside surfaces approaches the dew point of the air within the bin more rapidly than the dew point can be lowered by the removal of moisture by ventilation, condensation will result.

In regions of low humidities and high temperatures, insulation as a means of preventing condensation is of less importance than in those regions where climatic conditions are more conducive to condensation. Because of lack of definite information with respect to

the temperatures occurring in grain bins in different localities it is not possible to state the amount of insulation required. Observations made of a large number of frame structures indicate that as dry wood is relatively a good insulator no special precautions with respect to condensation are required for wooden bins.

Metals conduct heat much more readily than do nonmetallic substances. For this reason metal grain bins, particularly the roofs, should be insulated to protect the grain from overheating caused by the sun's rays and from condensation due to marked changes in temperature. Thoroughly dry grain is not affected by the sun's heat.

#### VENTILATION

Damp grain should be kept cool and well ventilated. If the farm storage is equipped with elevating machinery, damp grain often can be dried sufficiently by frequently transferring the grain from one bin to another during warm, dry weather. If the grain contains



FIGURE 20.—Metal bins made from an old silo. They were covered with asphalt paint to waterproof the joints, but this coating adds to the absorption of the sun's heat

only a slight excess of moisture, it can be dried in bins equipped with ventilating ducts open at each end to outside air, such as shown in Figure 21. The provision of a ventilator and ventilating ducts does not alone constitute good ventilation for they must be properly operated. The ducts should be provided with doors which may be closed readily at night or whenever the weather conditions are not favorable for ventilation, as on a damp day following cool weather when the introduction of damp air into a mass of grain of lower temperature would cause condensation and increase rather than decrease the moisture content of the grain. In a test in North Dakota, wheat having a moisture content of from 16 to 18 per cent was successfully stored in such bins after it had been cleaned.

The condition of the circulated air affects the drying process. Natural drying is accomplished by introducing into the bin outside air of proper condition. During the early period of storage the air within the bin is likely to be of comparatively high humidity owing to the respiration of the grain. If outside air of the same temperature but of lower humidity is introduced and circulated through

the bin it will absorb moisture from the inside air and the grain. If the outside air is of lower temperature and of even higher humidity than the air within the bin, the effect is the same since the outside air is warmed and its capacity for holding moisture is increased.

Newly threshed grain having an excess of moisture respire freely and throws off heat and moisture, particularly during the early part of the storage period. It is therefore necessary to provide for circulation of air over the top of the mass. In storages having open-top bins this circulation may be provided by opening the windows. Separate portable or permanent bins with roofs should be provided with air inlets in the side walls and a central outlet in the roof. All openings should be constructed so as to prevent entrance of snow or rain.

#### RAT PROOFING

Rats and mice are responsible for heavy losses in stored grain. If rodents are furnished good harborage near a supply of food, they increase rapidly in number. The remedy is to destroy as many of the rats and their burrows as possible and to make all storage structures rat proof.

Rats seek shelter in dark places beneath buildings and in rubbish piles where their runways will be unmolested by natural enemies. If the floor of the granary is a foot or more above the ground, rats are less likely to burrow under the building, and dogs and cats can get at them readily. If the building is set close to the ground rats, in burrowing, will pile up mounds of moist earth against the floor joists and sills, often causing early rotting of these timbers.

Metal bands 8 to 10 inches wide are sometimes nailed to the sides of the building, forming a belt beyond which the rats are unable to climb. Figure 22 shows ineffective use of metal stripping as a rat barrier. Metal strips sometimes are nailed around the top of the supporting posts of the granary as shown in Figure 13. If the foundation is built of loosely laid stone as in Figure 23, it is impossible to keep rats out and once they are in it is very difficult to dislodge them.

Trapping and poisoning are effective measures in the eradication of rats.<sup>7</sup> Poisons, however, because of their danger to human beings and to farm animals, must be employed cautiously. Recent experiments by the Bureau of Biological Survey show that red squill

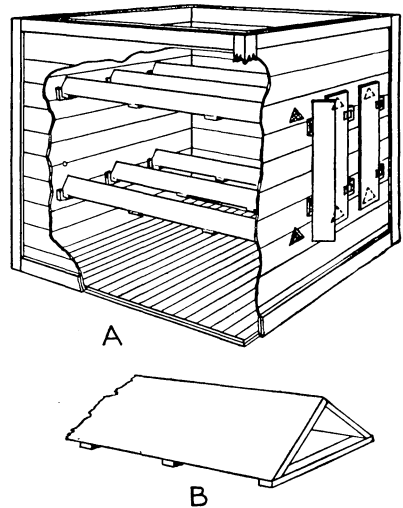


FIGURE 21.—Ventilated grain bin: A.—View of ventilators in position in the bin. These are placed 20 inches apart in tiers which are also 20 inches apart, one above the other. Screened openings in the bin walls at the ends of each ventilator are fitted with doors, which when closed prevent circulation of air. B.—Construction of ventilators

<sup>7</sup> U. S. Dept. Agr. Farmers' Bul. 1533, Rat Control.

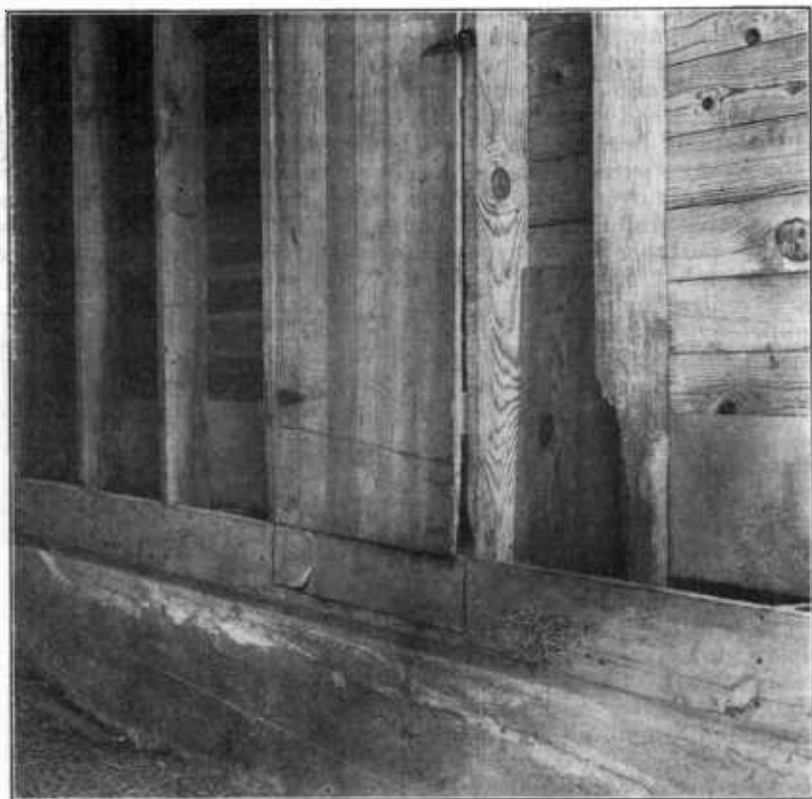


FIGURE 22.—A misdirected effort in rat proofing. The metal band at the junction of floor and wall of a bin failed to exclude rats as they gained entrance through the door and by climbing the studs

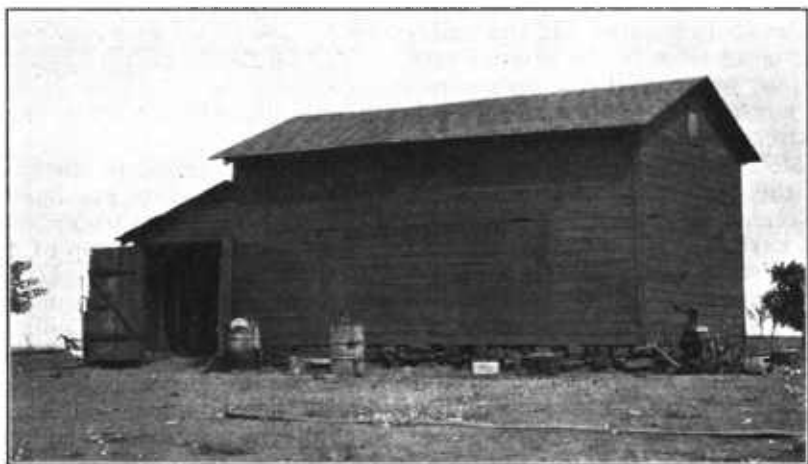


FIGURE 23.—A foundation of loose stones permitting entrance of rodents and affording excellent protection against their natural enemies

is an efficient and economical poison. Since it has been fed to cats, dogs, poultry, and pigs without apparent ill effects, its use in baits is to be recommended in preference to the more active poisons.

### HANDLING GRAIN FOR STORAGE

Methods of handling grain have changed with improvements in harvesting machinery and equipment. The binder and separator, with wagon transportation and hand labor, are now being replaced quite generally in many areas by the combine, supplemented by the truck and the power elevator. Scooping grain into the bin, as shown in Figure 24, was all right in the days of small acreage and cheap labor, but to-day it is wasteful of man power. The combine



FIGURE 24.—The old hand method of handling grain, adequate for small crops but wasteful of man-labor and expensive in handling large quantities of grain. Note the convenient height of grain doors

has so speeded up the cutting and threshing that hand methods of transferring grain from wagon or truck into storage bins retard the harvest unless extra labor is employed.

The handling of grain in sacks from the thresher or combine to the market is a practice that is rapidly being abandoned. Little human effort is required to move grain in bulk, whereas sacks must be sewed, lifted, and piled to be again lifted and loaded on to trucks or wagons. When grain is handled in bulk, advantage may be taken of the fact that it flows readily. Practically no man power is then required to move it at a speed impossible to attain with the bag system. Additional information on the economy and ease of bulk handling of grain is given in Farmers' Bulletin 1290, *The Bulk Handling of Grain*.

Grain should never be stored in old bins until they have been thoroughly cleaned. This is especially important when the previous crop was infested with weevils or disease. Dust and old grain left in corners and cracks usually are infested with weevils which attack the new crop.<sup>8</sup> If short pieces of boards are cut between the studs, as shown in Figure 18, the bins may be more easily swept clean.

#### POWER ELEVATING MACHINERY

Grain-elevating machinery of varied design is now available for farm use. There are two principal types, portable and stationary.



FIGURE 25.—A portable elevator used for filling a granary through a gable window

A portable elevator (figs. 25 and 26) consists of three principal parts, namely, the wagon jack or dump, the receiving hopper, and the elevator leg. It may be driven either by horse or by belt power. These elevators usually are light and strong and generally are mounted on wheels so that they may be readily moved about the farm.

<sup>8</sup>U. S. Dept. Agr. Farmers' Bul. 1483, Control of Insect Pests in Stored Grain.

An overhead dump consists of a steel or wooden frame (fig. 25) equipped with a windlass, cables, and pulleys. The cables are attached to the hubs of the front wheels of the wagon, power is applied to the windlass, and the front end of the wagon is raised to the desired height.

The receiving hopper usually is attached to the elevator leg and generally is so arranged that it may be either raised (fig. 26) or swung to one side so that the load of grain may be driven into position for dumping. The portable elevators illustrated can not be operated efficiently with the leg at an angle much greater than  $45^\circ$  because of the small quantity of grain that can be kept ahead of the cross bars as they move up the trough. The capacity of these elevators under normal conditions of operation is approximately 500 bushels per hour.

By means of the portable elevator grain easily may be put into any bin of moderate height including overhead bins in barns and



FIGURE 26.—A portable elevator with grain hopper in raised position. This granary is a little too long to permit of filling it through the one central hatch door in the roof

other structures. Grain may be elevated through a gable door or window, as shown in Figure 25, or through a hatch, as illustrated in Figure 26. The power elevator permits of grain storages of greater height, as shown in Figure 27, and relatively cheaper construction than those in which hand methods of filling are employed, because of the smaller foundation and smaller roof required for the same storage capacity. Figure 28 shows a granary with a central cupola to which the grain is raised by means of an elevator and from which the grain is then spouted to any of several bins. The central cupola permits of greater ease in handling the grain spouts when the grain is distributed to the several bins. The windows in the cupola light the interior of the granary and also provide a means of ventilating the building.

Stationary cup elevators, usually operated by belt power, may be installed within either an old or a new storage building. An elevator



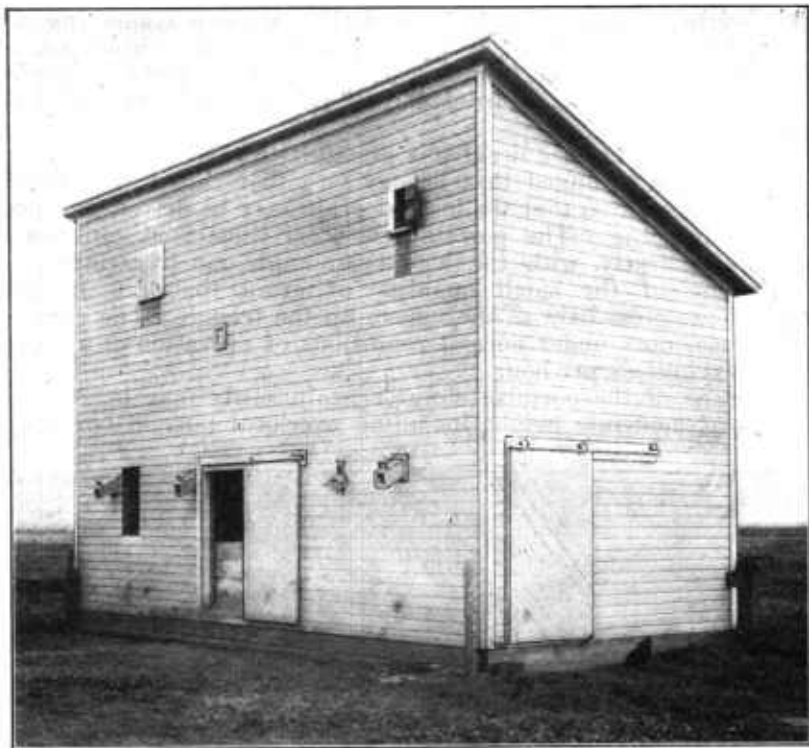


FIGURE 27.—A farm granary which because of its height and arrangement makes the use of a portable elevator advantageous. The grain spouts allow of the removal of several hundred bushels of grain by gravity

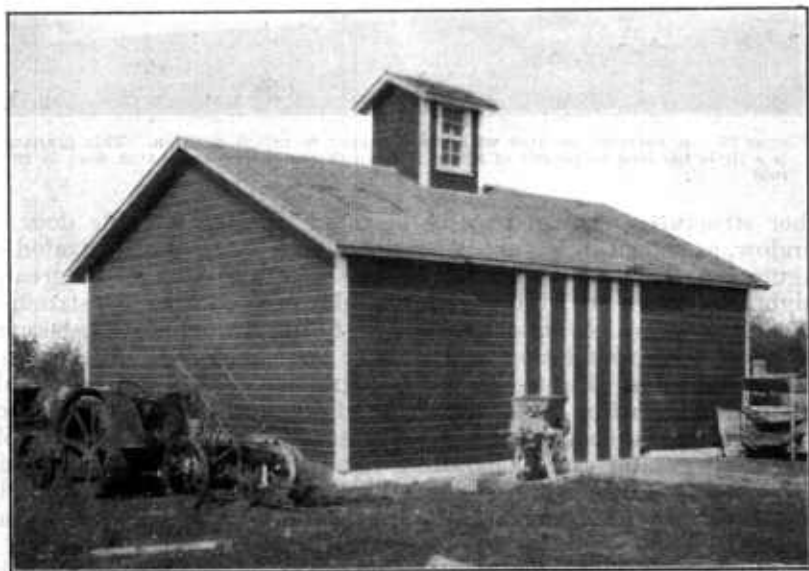


FIGURE 28.—This granary is filled by means of a portable elevator through the central cupola, which is an improvement on the covered hatch

leg extends to a sufficient height to permit delivery of the grain to a central swinging spout whereby it may be distributed to any bin. The spout should have a slope of not less than 40°. Either a pit or a hoist dump may be used in connection with this type of elevator. In order that the grain shall flow readily from the dump or bin to the elevator boot and from the head of the elevator to the bins, the storage structure should be designed in accordance with the dimensions of the equipment to be installed. The necessary information should be obtained from the manufacturer of the equipment. In many instances it has been found, after the building was up and the elevator on the ground, that it could not be installed to the best advantage—being either too long or too short, or possibly too wide,

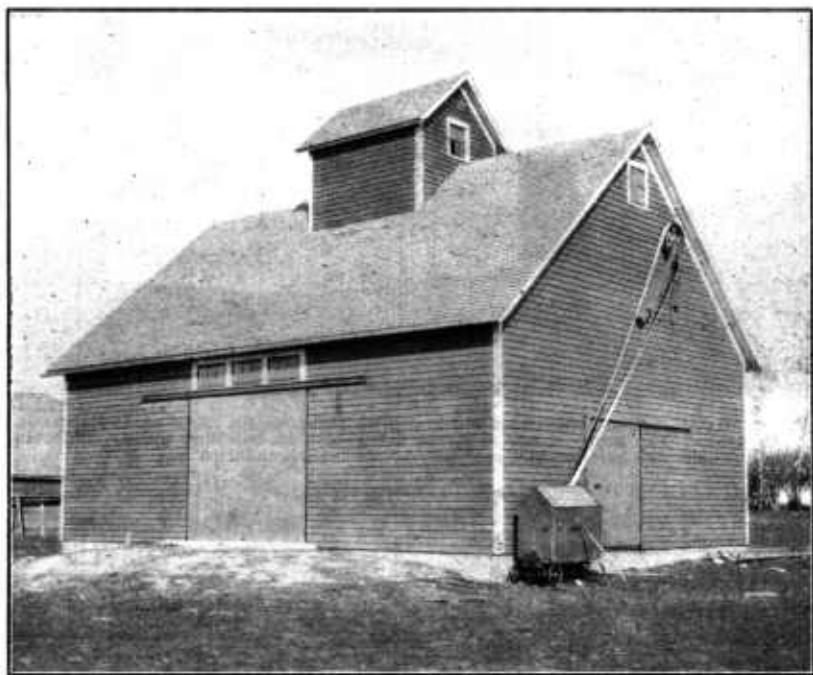


FIGURE 29.—A farm elevator 26 by 38 by 12 feet, balloon framing. Bins are filled by means of an inside cup elevator, driven by a portable engine, which may also be used to drive a feed grinder by belting through the door. Windows over the driveway door light the interior permitting inside work during bad weather

for the space allotted. Both the pit, or underground hopper, and the elevator boot should be protected against the entrance of water. Provision should be made for easy access to the boot with ample room for cleaning and repairing. It should be thoroughly cleaned at the end of the harvest season as grain left in the boot may spoil and affect the grade of grain handled later.

Elevating machinery is practically indispensable in handling large quantities of bulk grain because of the saving in time and labor. It may be used to deliver grain from wagon or truck to bin, from bin to bin, from bin to wagon or truck, and from wagon or truck to railroad cars.

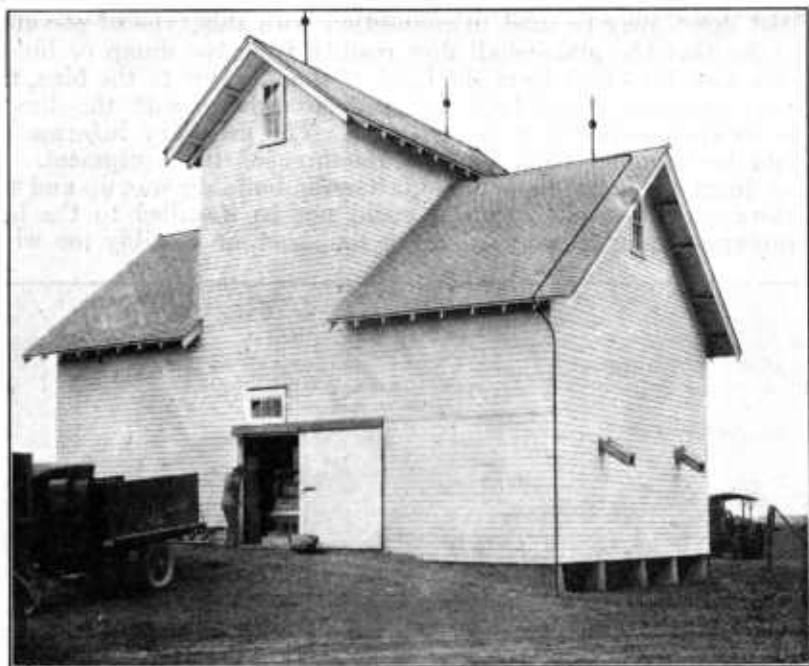


FIGURE 30.—A well-equipped farm elevator with facilities for cleaning and elevating the grain. The grain spouts decrease labor cost in handling grain. Lightning rods protect the building and contents. Note high foundation



FIGURE 31.—Type of farm grain elevator of crib construction suitable for storing from 6,000 to 10,000 bushels. The storage contains 10 bins with inside dump and elevator, and space for cleaning and grinding machinery. Design No. 1878. Estimated cost, not including equipment, from \$3,000 to \$5,500, according to capacity

## TYPES OF STORAGE

The farm storage may consist of an elevator, granary, portable bins, or emergency bins.

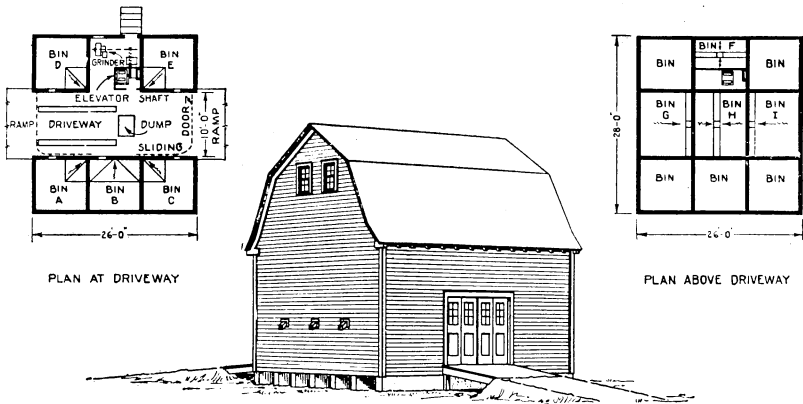


FIGURE 32.—Type of farm grain elevator of balloon construction suitable for storing from 4,000 to 6,800 bushels. The storage contains four hoppers and five partly hoppers, central driveway, space for cleaning and grinding, and elevator. Design No. 2394. Estimated cost, exclusive of machinery, \$2,500 to \$4,000, according to capacity.

## ELEVATORS

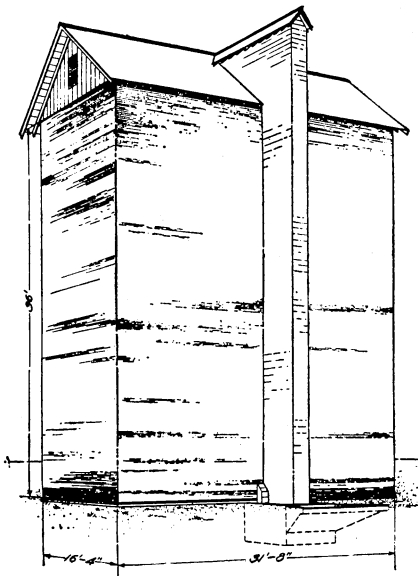


FIGURE 33.—Two-bin crib grain storage with outside dump and inclosed elevator. A shed for grinding and cleaning may be added. Design No. 2297. Estimated cost, exclusive of machinery, from \$2,500 to \$3,000.

The farm grain elevator was developed to reduce the cost of handling and storing grain on large grain-producing farms. It has also come into use on stock farms where large quantities of grain are fed. In such structures extra space and equipment are desirable for the handling of grain in conditioning, cleaning, and grinding. The amount and kind of equipment required for these purposes depends upon whether the grain is to be sold as market grain or seed, or is to be used on the farm for feed. The farm elevator may easily pay for itself in a short time through the prevention of overheating of high-moisture grain by making it possible to transfer the grain from bin to bin to reduce its moisture content, and through the removal of foreign material or dockage from the grain before it is sold on the market. Figures

15, 29, 30, 31, 32, and 33 illustrate several types of farm grain elevators.

## GRANARIES

The permanent granary is usually of smaller capacity than the type of storage classed as an elevator and may or may not be filled by machinery. It often may be so located that the natural ground

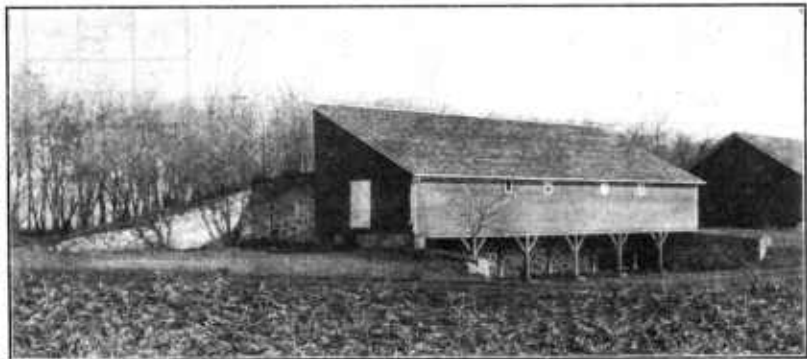


FIGURE 34.—A hillside granary with wagon ramp and retaining wall on the filling side. A 6-inch space between the masonry and the frame walls provides for air circulation between them. An 8-foot clearance beneath the floor permits the filling of wagons through spouts in the bottoms of the bins

levels permit of handling by gravity all or a large part of the grain going into or out of the granary. To permit of this, a little grading or other construction work sometimes is necessary to obtain the



FIGURE 35.—A farm granary with four bins of 600 bushels capacity each. High foundation keeps the timbers dry. Inadequate bearing afforded by the center 2 by 4 inch sill caused crushing of joists on lower edges

required floor and drive levels. Such an arrangement is desirable provided the extra cost of construction does not exceed the cost of mechanical equipment for handling the grain. A granary in which

the grain is handled partly by gravity is shown in Figure 9. Figure 34 illustrates an instance of gravity handling in which the extra cost of construction—chiefly retaining walls, excavation, and fill—would exceed, at present prices, that of elevating machinery.



FIGURE 36.—A common type of granary 14 by 24 feet, with four bins each of 450 bushels capacity, which may be filled by hand or by means of a portable elevator. Space for cleaning and treating seed is provided. Design No. 984. Estimated cost, \$1,000



FIGURE 37.—A combination shop and granary, 24 by 26 feet, with concrete walls and metal roof

Figures 35 and 36 show permanent granaries in which the grain is loaded and removed by hand. Space no longer needed for horse stalls, or other unused space in the stable or in the loft above, often

may be utilized for this purpose. Wheat stored in bins within a barn has greater protection from the heat of the sun than that stored in small, separate granaries. The portable elevator often makes available for grain storage space that otherwise would be inaccessible.

Grain bins often are built in combination with storage space for other crops, or for machinery, implements, or automobiles. Figures 6, 37, 38, and the cover page afford suggestions of arrangement which may be of aid to those contemplating the erection of a storage building.

#### PORTABLE BINS

Portable bins may be of wood or sheet metal and should be so built that they may be easily moved from place to place. They may

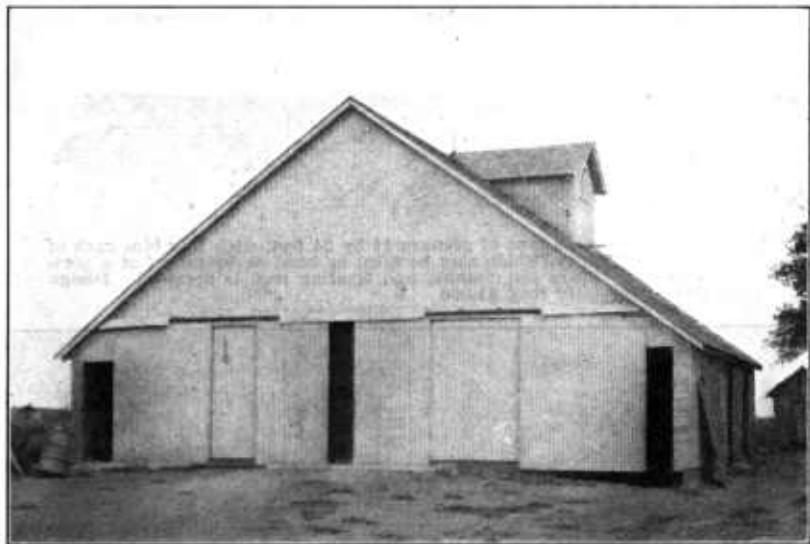


FIGURE 38.—A combination granary and machine shed with metal sheathing. The grain bins are on both sides of the central driveway. Machinery is stored in the sheds at the sides. The grain is handled with a homemade cup elevator

be of knockdown (fig. 39) or of rigid construction, the latter usually being provided with skids for ease in moving. (Fig. 40.) They range in capacity from 500 to 1,500 bushels, most of them holding less than 1,000 bushels.

The knockdown type is used chiefly in locations where it is impracticable to move bins of rigid construction or where it is desired to shelter the bins, when not in use, in a compact space. Because of the greater difficulty in keeping them grain tight, knockdown bins are not as desirable as those of rigid construction.

The principal advantage of portable bins is the saving of labor which results from their use in the field. The grain can be stored in them directly from the thresher, or with a short haul from the

thresher or combine, thus saving time and hauling expense during the busy season. The life of a portable bin is shorter than that of the permanent forms of storage. The latter, usually, are the more

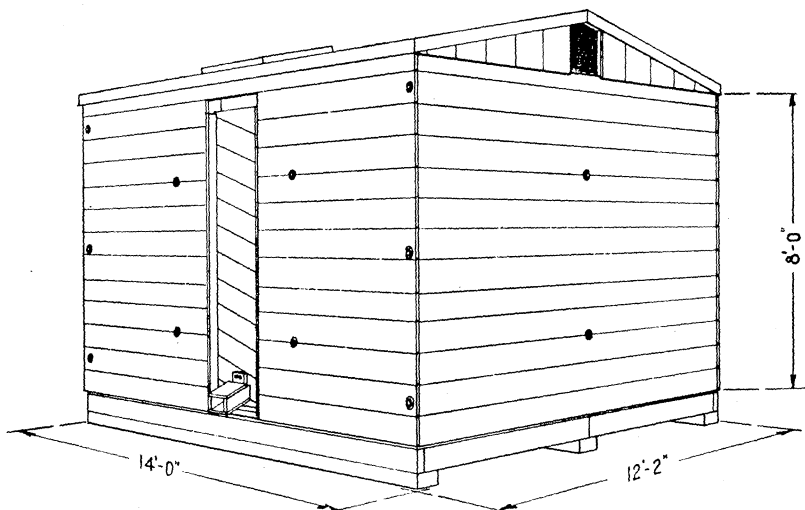


FIGURE 39.—Knockdown bin of 1,000 bushels capacity. Design No. 2391  
Estimated cost, \$250

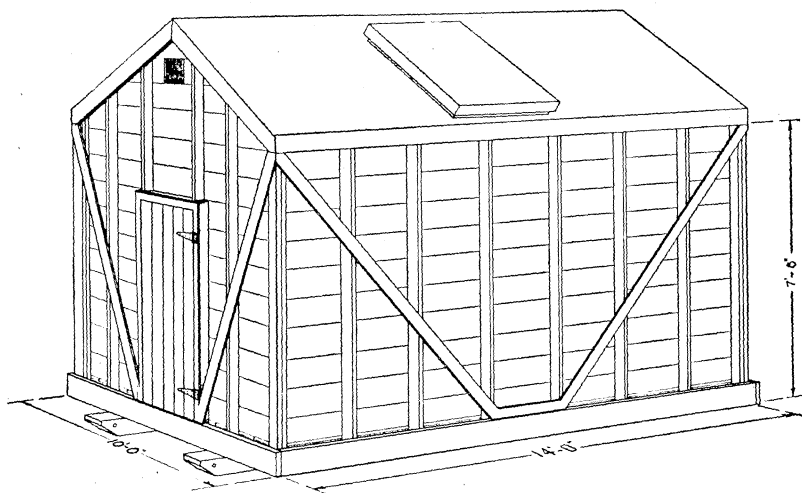


FIGURE 40.—Portable wooden grain bin holding 660 bushels. Design No. 2294.  
Estimated cost, \$150

economical when large quantities of grain are to be stored. Some of the common forms of portable bins are shown in Figures 40, 41, 42, and 43.



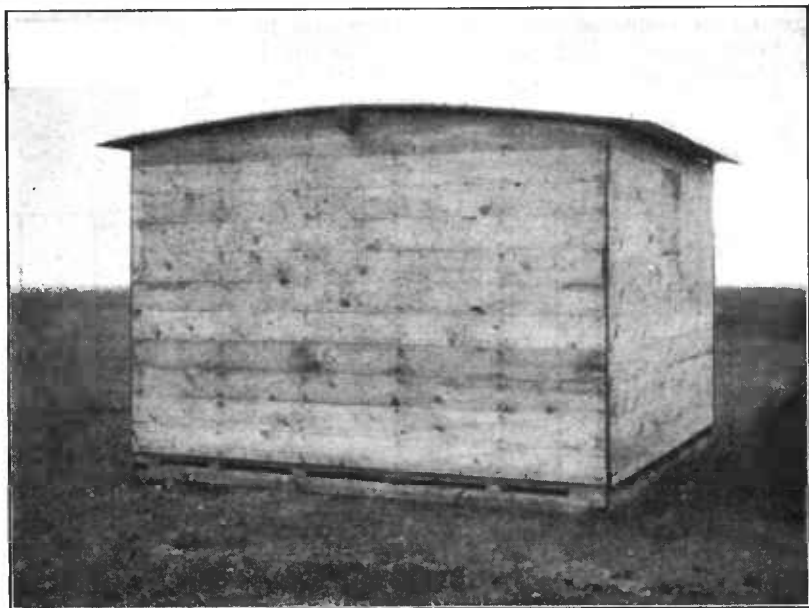


FIGURE 41.—A portable grain bin of box-car type 10 by 10 by 6 feet having a capacity of 480 bushels



FIGURE 42.—A portable bin mounted on skids used temporarily as a summer bunk house

## METAL BINS.

Galvanized-metal bins, as both portable (fig. 43) and permanent (fig. 44) installation have been used satisfactorily for the storage of bulk grain in many localities. They are easy to handle and erect, are vermin-proof, and provide fire protection. Their cost is not prohibitive. Because of their light construction they are often subjected to careless handling and consequent damage in moving, and they are easily damaged by the wind. Bins more than 10 feet in diameter, especially when of light-gage metal, should be strongly braced inside to withstand wind pressure when empty. As portable bins they should be anchored with guy wires to temporary posts.



FIGURE 43.—A 500-bushel portable bin of corrugated metal, mounted on skids

When set in permanent locations they should be firmly anchored to concrete foundations. The durability of metal bins is dependent upon the gage or weight of the metal and the quality of the galvanizing. For long life the metal should be of not less than No. 20 gage. Lightweight metal has less structural strength and is subject to rapid corrosion unless well protected by paint.

A portable metal bin of 500 bushels capacity costs from \$90 to \$150 and a 1,000-bushel bin from \$125 to \$200, depending upon the gage and quality of the metal. To these prices the cost of erection must be added and, if the location is to be permanent, the cost of suitable foundations. Generally, erection requires one day's time of two men. Foundations will cost from \$15 to \$35 according to the kind and local conditions.

## EMERGENCY STORAGE

Emergency, or temporary, storage sometimes is necessary because of an unusually large crop, an abnormal market situation, accidental loss of permanent storage, lack of trucks or wagons, bad roads, or some other circumstance.

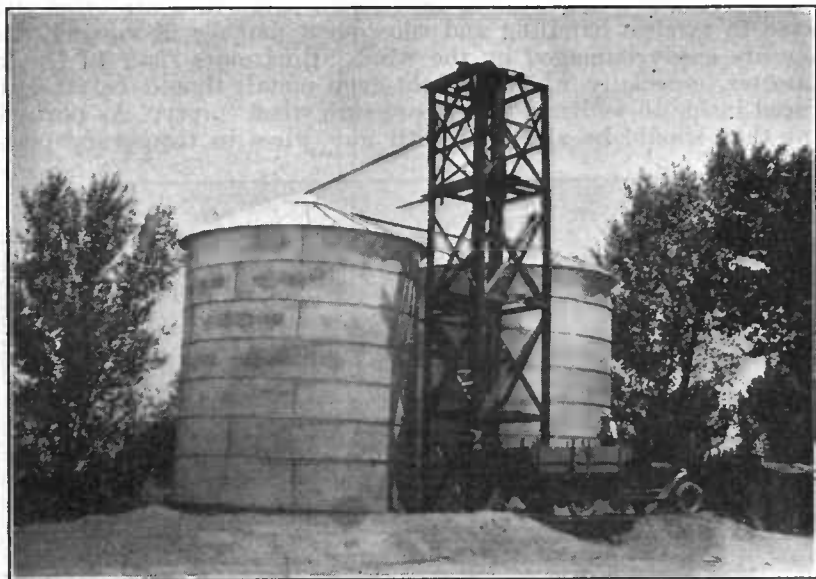


FIGURE 44.—Two metal bins with outside bucket elevator. This may be erected quickly to serve either as a temporary storage or as the beginning of a permanent structure. Other bins may be added and the elevator may be inclosed

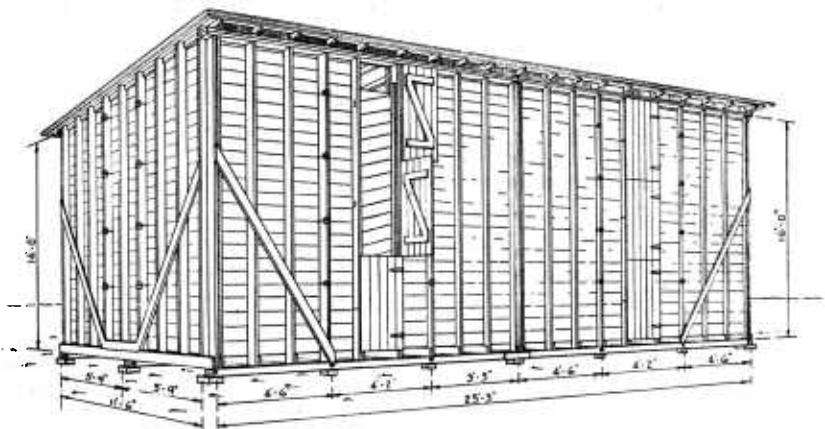


FIGURE 45.—Two-bin temporary grain storage of 2,800 bushels capacity. Additional bins may readily be added at the ends if desired. Design No. 2393. Estimated cost, \$600

Generally, grain in temporary storage should be protected from the weather and from ground moisture. Figure 45 illustrates a temporary bin providing such protection. In the semiarid regions

grain sometimes is piled directly on the ground for a short time with or without a retaining inclosure. Grain so stored is subject to damage by rains, as well as by rodents and other field pests, and must be fenced in, to prevent loss from livestock. Such storage is illustrated in Figure 46. The greatest damage from moisture, to

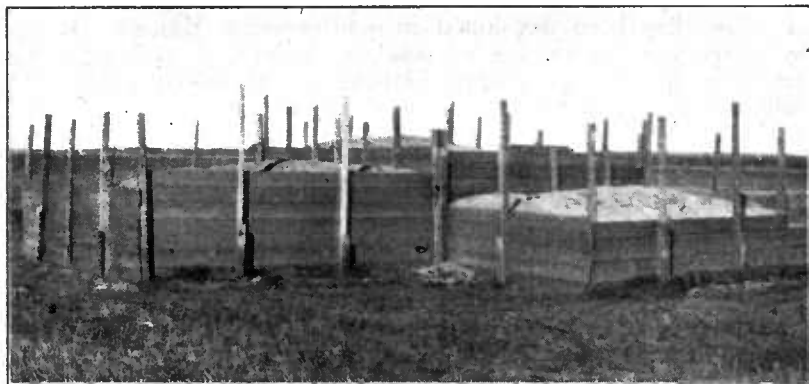


FIGURE 46.—An emergency storage built of posts set in the ground and 1-inch boards. It affords no protection from weather. Spoiled grain was found at the top and bottom of the pile and next to the board walls

grain piled on the ground in the open, occurs over the surface and at the bottom of the pile. Waterproof paper, laid on the ground, lends protection against damage from ground moisture. Heaped grain suffers less damage than that piled with a flat surface.



FIGURE 47.—A temporary grain storage of metal with roof blown off. The grain is covered with wild hay

A better type of temporary storage is shown in Figure 47. The higher metal inclosure affords better protection from field pests and livestock. A covering of hay can not be recommended as it affords little or no protection from rain. Grain stored in this way usually takes a lower grading when marketed than it would had it been properly stored.

Portable metal bins often are used in emergencies. In localities where they are readily available the time and labor saved by the purchase of ready-made bins may offset any additional cost.

Grain sometimes is stored temporarily on the floor of or in bins erected in buildings designed for other purposes. Figure 48 is an interior view, taken during construction, of a new type of machine shed which has been developed in southwestern Kansas. It provides space for the storage of combine harvesters and other machinery, or for the temporary housing of harvested grain. The stability of this particular structure would be increased by the addition of wind bracing and the stiffening of some of the roof members.

#### LABOR-SAVING DEVICES

There are a number of minor features of storage design which save time and labor in the handling of grain. Grain-discharge spouts, set in the sides of bins, as shown in Figures 6, 27, and 30,

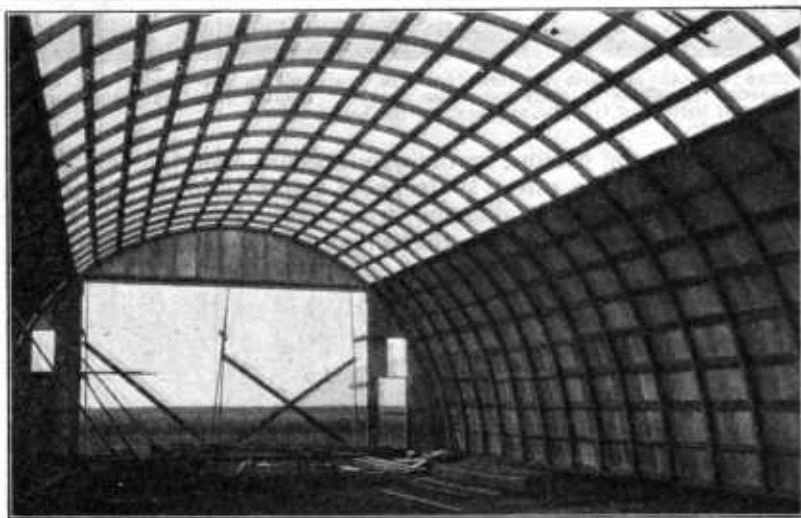


FIGURE 48.—An interior view of hangar type of machine shed, 40 by 100 feet, under construction. It will be used also for temporary storage of grain. The ribs are built up of 1-inch boards and are spaced 4 feet apart. The covering is of corrugated metal.

expedite the unloading of grain bins. When properly placed, they permit of the unloading by gravity of a large part of the contents of the bins, thus saving considerable manual labor or mechanical power. The spouts shown in Figure 6 are of little value because of the small quantity of grain above the spout level.

A swivel metal spout in the bottom of an overhead hopper bin is shown in Figure 49. A lever attached to the gate would make for greater convenience in operation. Deep bins should be equipped with metal discharge spouts, or with wood spouts that are banded with metal, and fitted with metal gates which are easily operated against the pressure of the grain.

Figure 50 illustrates the use of a scoop door which serves as an apron when the bin is being filled and as a chute when the grain is being removed. It is preferable to the cloth or sack apron shown in Figure 2 as less grain is spilled upon the ground. The door illustrated is 30 by 36 inches and is somewhat larger than those in common use. The bottom of this door is 7 feet above grade and is a little too low to permit of filling the bin to full capacity; grain may be scooped easily to a height of 8 or 8½ feet. (Fig. 24.)

Figures 45 and 51 show the proper method of making retaining boards for high bin doors. Cutting the boards at an angle or bevel makes it possible to remove them easily without raising each one to the top of the door. Moreover, they are less apt to bind than are square-cut boards such as are shown in Figure 43. The device

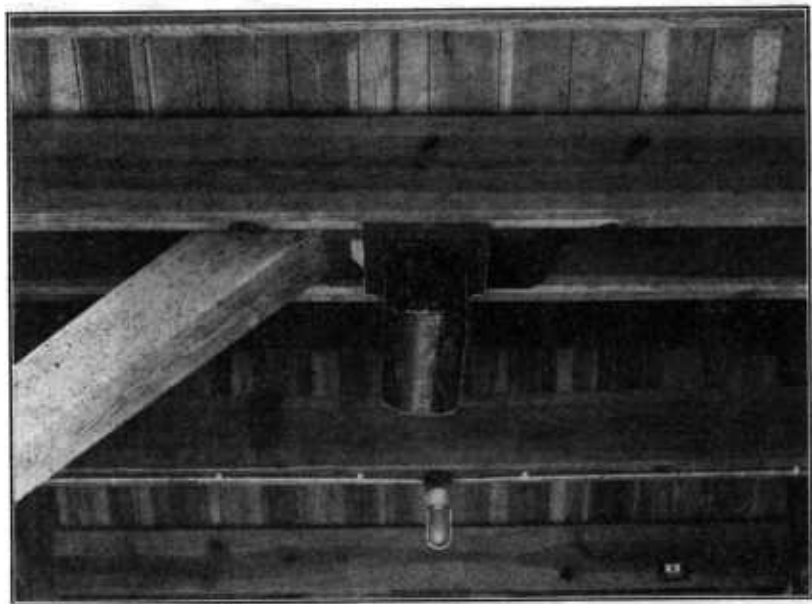


FIGURE 49.—An adjustable swivel grain spout in the bottom of an overhead hopper bin. Metal spouts are more easily operated and are more durable than wood spouts

occupying the lower part of the door opening (fig. 51) is useful when small quantities of grain are to be removed from the bin as in the daily feeding of stock. If the opening is made 2 feet 4 inches wide with a gate in the top, a bushel basket may be filled quickly. A smaller opening will serve for scooping.

Owing to the use of both trucks and wagons of varying lengths in hauling grain to the storage elevator, a square dump opening with a heavy hinged door and dump logs in fixed position are often a disadvantage. The logs and the open hinged door fix the position of the rear wheels of the truck or wagon, which may be too long for the logs. Improved equipment consists of a long dump opening fitted with a heavy iron grating, over which loaded trucks or wagons may be driven, and a wagon hoist of hand or air-lift type so placed that the grain from the shortest of wagons or trucks will fall on the

grating. Grain from longer vehicles also falls on the grating but farther from the end nearest the hoist. The grating usually consists of  $\frac{1}{2}$  by  $3\frac{1}{2}$  inch iron bars spaced  $2\frac{1}{2}$  inches apart and tilted in the direction of travel to facilitate the flow of grain. The grating may be made in sections permitting of ready removal.

#### PLANS AVAILABLE

The plans referred to in this bulletin should be of help in planning and erecting suitable structures. They are intended to meet, in a general way, conditions commonly found on farms in the wheat belt.

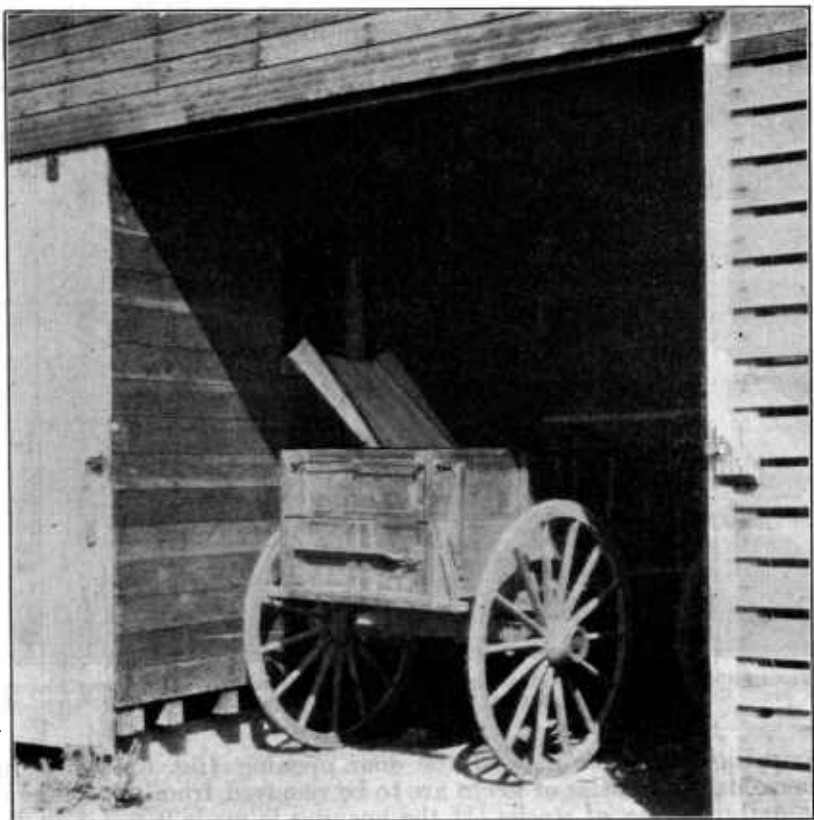


FIGURE 50.—A grain-bin door which may be used as an apron when unloading a wagon, as a chute when loading it

They may be modified with respect to dimensions, arrangement, and details of construction. Complete working drawings for the storages shown in Figures 31, 32, 33, 36, 39, 40, 45, and that referred to in the legend of Figure 3, may be had by those who contemplate building, upon application to the Division of Agricultural Engineering, Bureau of Public Roads, United States Department of Agriculture, Washington, D. C. In requesting a plan reference should be made to the design number given in the legend. Working drawings

for the existing buildings, photographic views of which are presented, can not be furnished. However, many suggestions may be obtained by the practical builder from the illustrations.

It is not feasible to state definitely the cost of storages erected by individual farmers from plans indicated as being available. Prices of materials vary with kind and locality. The cost of rural labor varies with locality and time of year. The efficiency of the labor employed and the experience and judgment of the builder in planning and executing the work are important cost factors.

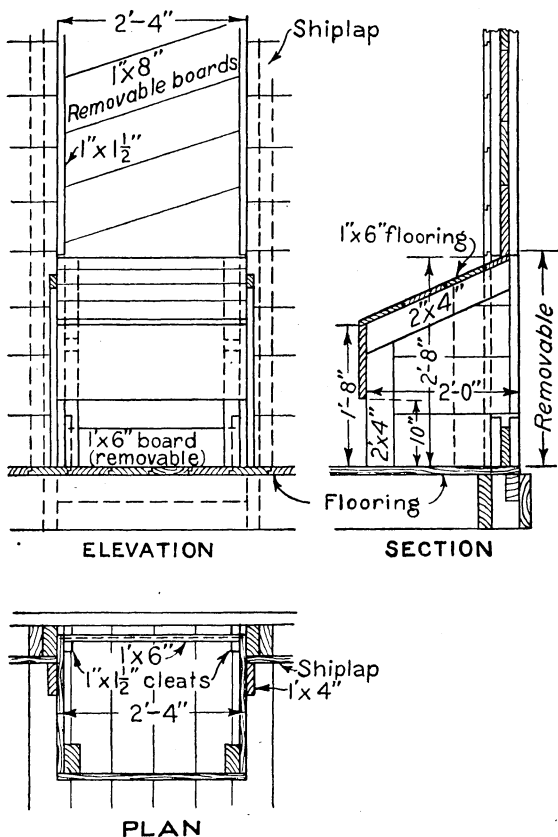


FIGURE 51.—Retaining boards for high bin-door openings.  
At the bottom of the opening is a scoop door which may be made to fit any opening

As a general guide to those considering the erection of any of the grain storages for which plans are available, estimated construction costs have been given in the respective legends under the illustrations. These estimates are based on prices of \$50 per thousand feet for framing lumber and \$60 for matched lumber, the labor cost being based on the best information available. A more accurate estimate may be obtained by submitting the bill of materials to local dealers. Information regarding the labor cost may be obtained from local carpenters or builders.



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